Nuclear Decay Worksheet

Directions: Name the type of emission(alpha/beta) and write an equation using the correct emission type.

1. Uranium-234 To Thorium-230 $^{234}_{92}U \longrightarrow {}^{4}_{2}He + {}^{230}_{90}Th$
2. Thorium-230 to Radium-226 $^{230}_{90}Th \rightarrow {}^{226}_{88}Ra + {}^{4}_{2}He$
3. Radium-226 to Radon-222 $^{226}_{88}Ra \rightarrow {}^{222}_{86}Rn + {}^{4}_{2}He$
4. Lead-214 to Bismuth-214 $^{214}_{82}Pb \longrightarrow {}^{0}_{-1}\beta + {}^{214}_{83}Bi$
5. Bismuth-214 to Polonium-214 $^{214}_{83}Bi \rightarrow {}^{214}_{84}Po + {}^{0}_{-1}\beta$
6. Polonium-214 to Lead-210 $^{214}_{84}Po \rightarrow {}^{210}_{82}Pb + {}^{4}_{2}He$

Directions: Write an equation for the following elements through the given emission type.

Alpha Decay:

1. Polonium-218 $^{218}_{84}Po \longrightarrow {}^{4}_{2}He + {}^{214}_{82}Pb$
2. Polonium-214 $^{214}_{84}Po \rightarrow {}^{4}_{2}He + {}^{210}_{82}Pb$
3. Radon-220 $^{220}_{86}Rn \rightarrow {}^{4}_{2}He + {}^{216}_{84}Po$
4. Radon-219 $^{219}_{86}Rn \rightarrow {}^{4}_{2}He + {}^{215}_{84}Po$

Beta Decay:

1. Lead-210 $^{210}_{82}Pb \longrightarrow {}^{0}_{-1}\beta + {}^{210}_{83}Bi$
2. Lead-214 $^{214}_{82}Pb \rightarrow {}^{0}_{-1}\beta + {}^{214}_{83}Bi$
3. Bismuth-210 $^{210}_{83}Bi \rightarrow {}^{0}_{-1}\beta + {}^{210}_{84}Po$

$\frac{1}{2}$ $\frac{1}{4}$ $\frac{1}{8}$ $\frac{1}{16}$ $\frac{1}{32}$ $\frac{1}{64}$ $\frac{1}{128}$ $\frac{1}{256}$ $\frac{1}{512}$ $\frac{1}{1024}$ $\frac{1}{2048}$

Half-life Practice Worksheet

1. Sodium-24 has a half-life of 15 hours. How much sodium-24 will remain in an 18.0 g sample after 60 hours?

initial = 18g
final = X
n = 4
TE = 60h
$t_{1/2}$ = 15h

$\frac{final}{initial} = \left(\frac{1}{2}\right)^n$ $\frac{X}{18} = \frac{1}{16}$ $X = 1.13g$

2. After 42 days a 2.0 g sample of phosphorus-32 contains only 0.25 g of the isotope. What is the half-life of phosphorus-32?

Initial = 2.0g
final = 0.25g
n =
TE = 42d
$t_{1/2}$ =

$\frac{0.25}{2.0} = \frac{1}{8} = \frac{1}{2}^n$ $n = 3$ $TE/t_{1/2} = 3$

$\frac{TE}{3} = t_{1/2} = 14d$

3. Polonium-214 has a relatively short half-life of 164 seconds. How many seconds would it take for 8.0 g of this isotope to decay to 0.25 g?

initial = 8.0g
final = 0.25g
n =
TE =
$t_{1/2}$ = 164s

$\frac{0.25g}{8g} = \frac{1}{32} = \frac{1}{2}^n$ $n = 5$

$TE/t_{1/2} = n$
$TE = n \cdot t_{1/2}$
$= 5 \times 164$
820 sec

4. How many days does it take for 16 g of palladium-103 to decay to 1.0 g? The half-life of palladium-103 is 17 days.

initial = 16g
final = 1g
n = 4
TE =
$t_{1/2}$ = 17d.

$\frac{1}{16} = \frac{1}{2}^n$ $n = 4$

$TE = n \cdot t_{1/2}$
$4 \times 17d = 68d$

5. By approximately what factor would the mass of a sample of copper-66 decrease in 51 minutes? The half-life of copper-66 is 5.10 minutes.

initial =
final =
n =
TE = 51min
$t_{1/2}$ = 5.10min

$51/5.10 = n = 10$

$\left(\frac{1}{2}\right)^{10} = \frac{1}{1024}$

6. In 5.49 seconds, 1.20 g of argon-35 decay to leave only 0.15 g. What is the half-life of argon-35?

initial = 1.20g
final = 0.15g
n =
TE = 5.49s
$t_{1/2}$ =

$\frac{0.15}{1.20} = \left(\frac{1}{2}\right)^n$ $n = 3$

$\frac{TE}{n} = t_{1/2} = \frac{5.49}{3} = 1.83s$ argon-35

HALF-LIFE PROBLEMS

Name_____ Block _____

1. An isotope of cesium (cesium-137) has a half-life of 30 years. If 1.0 g of cesium-137 disintegrates over a period of 90 years, how many g of cesium-137 would remain?

initial = 1g
final =
n = 3
TE = 90
$t_{1/2}$ = 30y

$\frac{x}{1} = \left(\frac{1}{2}\right)^3 = \frac{1}{8}$ $\boxed{x = 0.13\,g}$

2. Actinium-226 has a half-life of 29 hours. If 100 mg of actinium-226 disintegrates over a period of 58 hours, how many mg of actinium-226 will remain?

initial = 100mg
final = x
n = 2
TE = 58
$t_{1/2}$ = 29 hr.

$\frac{x}{100mg} = \left(\frac{1}{2}\right)^2 = \frac{1}{4}$ $\boxed{x = 25\,mg}$

3. Sodium-25 was to be used in an experiment, but it took 3.0 minutes to get the sodium from the reactor to the laboratory. If 5.0 mg of sodium-25 was removed from the reactor, how many mg of sodium-25 were placed in the reaction vessel 3.0 minutes later if the half-life of sodium-25 is 60 seconds?

↳ in the lab.

reator → lab 3min

initial = 5.0g
final =
n = 3
TE = 3min
$t_{1/2}$ = 60s.

$\frac{x}{5.0mg} = \left(\frac{1}{2}\right)^3 = \frac{1}{8}$ $\boxed{x = 0.63\,mg}$

4. The half-life of isotope X is 2.0 years. How many years would it take for a 4.0 mg sample of X to decay and have only 0.50 mg of it remain?

initial = 4.0mg
final = 0.5mg
n = 3
TE =
$t_{1/2}$ = 2.0 yr

$\frac{0.5}{4.0} = \frac{1}{8} = \left(\frac{1}{2}\right)^n$ $n = 3$ $3 \times 2.0 = \boxed{6yrs}$

5. Selenium-83 has a half-life of 25.0 minutes. How many minutes would it take for a 10.0 mg sample to decay and have only 1.25 mg of it remain?

initial = 10mg
final = 1.25mg
n =
TE =
$t_{1/2}$ = 25.0min

$\frac{1.25}{10} = \left(\frac{1}{2}\right)^n = \frac{1}{8}$ $n = 3$ $3 \times 25min = \boxed{75min}$

6. The half-life of Po-218 is three minutes. How much of a 2.0 gram sample remains after 15 minutes? Suppose you wanted to buy some of this isotope, and it required half an hour for it reach you. How much should you order if you need to use 0.10 gram of this material?

A. initial =
final =
n = 5
TE = 15min
$t_{1/2}$ = 3min

$\frac{x}{2} = \left(\frac{1}{2}\right)^5$ $\frac{x}{2} = \frac{1}{32}$ $\boxed{x = 0.063\,g}$

B. $\frac{0.10}{x} = \left(\frac{1}{2}\right)^n$ TE = 90min, $t_{1/2}$ = 3min, n = 30 $\boxed{x = 1.1 \times 10^9\,g}$

Transmutation

Name: _____

Transmutation is the process of converting one element into another (using bombardment with high energy particles). The **target nucleus** is the isotope which is bombarded, the **projectile** is the particle fired at the nucleus, the **product** is the new nucleus produced by the reaction, and the **ejected particle** is the light nucleus or particle emitted in the reaction. This bombardment takes place in a particle accelerator (cyclotron, synchrotron, linac, etc.). Many of the radioactive products of nuclear bombardment are useful in medicine and industry as tracers, etc..

Part 1: Fill in the blank in each transmutation reaction with the correct particle, and label each particle as the target, projectile, product, and ejected particle.

1. $^{14}_{7}N + {}^{4}_{2}He \longrightarrow {}^{1}_{1}H + {}^{17}_{8}O$

2. $^{4}_{2}He + {}^{27}_{13}Al \longrightarrow {}^{30}_{15}P + {}^{1}_{0}n$

3. $^{246}_{96}Cm + {}^{12}_{6}C \longrightarrow {}^{254}_{102}No + 4\,{}^{1}_{0}n$ (there are 4 neutrons)

4. $^{59}_{27}Co + {}^{1}_{0}n \longrightarrow {}^{60}_{27}Co$

5. $^{97}_{42}Mo + {}^{1}_{1}H \longrightarrow {}^{97}_{43}Tc + {}^{1}_{0}n$

6. $^{209}_{83}Bi + {}^{4}_{2}He \longrightarrow {}^{1}_{0}n + {}^{212}_{85}At$

7. $^{1}_{1}p + {}^{239}_{92}U \longrightarrow {}^{238}_{93}Np + 2\,{}^{1}_{0}n$ (2 neutrons)

8. $^{98}_{42}Mo + {}^{1}_{0}n \longrightarrow {}^{0}_{-1}e + {}^{99}_{43}Tc$

9. $^{1}_{0}n + {}^{40}_{20}Ca \longrightarrow {}^{40}_{19}K + {}^{1}_{1}H$

10. $^{2}_{1}H + {}^{3}_{2}He \longrightarrow {}^{4}_{2}He + {}^{1}_{1}H$

Part 2: Rewrite the following reactions in symbol form:

11) A neutron hits a uranium-235 atom, splitting it into a barium-140 atom, a krypton-93 atom and 3 neutrons.

$$^{235}_{92}U + ^{1}_{0}n \longrightarrow ^{140}_{56}Ba + ^{93}_{36}Kr + 3\,^{1}_{0}n$$

12) A zirconium-95 atom undergoes beta decay to become stable.

$$^{95}_{40}Zr \longrightarrow ^{0}_{-1}B + ^{95}_{41}Nb$$

13) A cobalt-59 nucleus is bombarded by a neutron to roduce cobalt-60.

$$^{59}_{27}Co + ^{1}_{0}n \longrightarrow ^{60}_{27}Co$$

14) An iron-58 is hit by a bismuth-209 nucleus to form meitnurium-266 and a neutron.

$$^{58}_{26}Fe + ^{209}_{83}Bi \longrightarrow ^{266}_{109}Mt + ^{1}_{0}n$$

15) A molybdenum-96 atom is hit by deutrium (hydrogen-2) to form technetium-97 and a neutron.

$$^{96}_{42}Mo + ^{2}_{1}H \longrightarrow ^{97}_{43}Tc + ^{1}_{0}n$$

Part 3: Determine the product nucleus of the following reactions:

16) A curium-246 nucleus is hit by a carbon-12 atom to produce what product nucleus and 4 neutrons?

$$^{246}_{96}Cm + ^{12}_{6}C \longrightarrow 4\,^{1}_{0}n + \boxed{^{254}_{102}No}$$

17) A lead-218 atom decomposes by alpha decay to produce what new nucleus?

$$^{218}_{82}Pb \longrightarrow ^{4}_{2}He + \boxed{^{214}_{80}Hg}$$

18) A neutron is fired at a uranium-235 atom, where the atom splits apart into what product atom along with zirconium-97 and 2 neutrons?

$$^{1}_{0}n + ^{235}_{92}U \longrightarrow ^{97}_{40}Zr + 2\,^{1}_{0}n + \boxed{^{137}_{52}Te}$$